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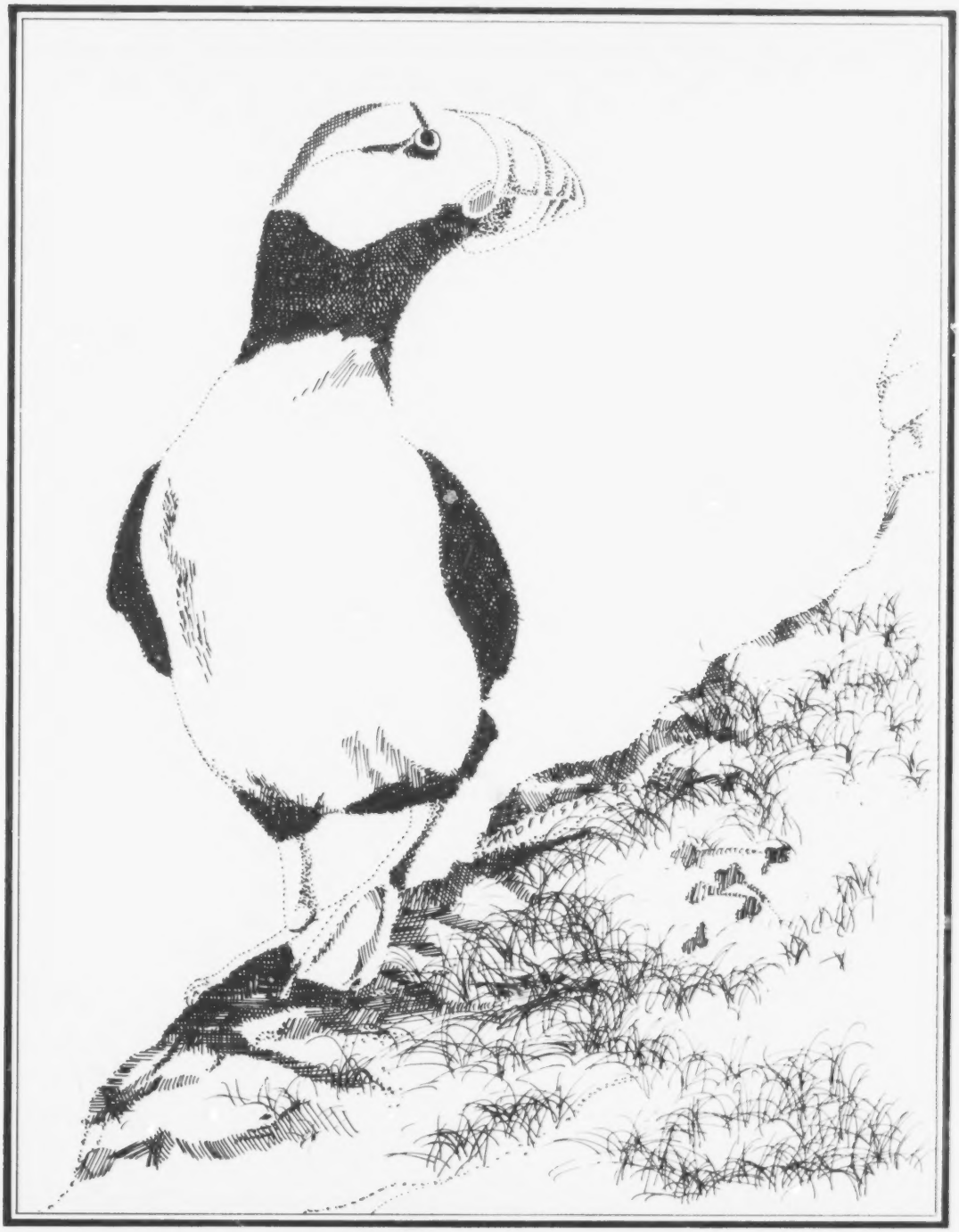
Highlights of Natural Resources Management 1989



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Highlights of Natural Resources Management 1989

Natural Resources Report NPS/NRPO/NRR-90/02

United States Department of the Interior
National Park Service
Natural Resource Publications Office

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Southern Bald Eagle Research in Everglades National Park

The southern bald eagle has been on the Federal Endangered Species list since 1967. Loss of habitat, persecution, and, finally, pesticide poisoning had caused this subspecies to disappear throughout most of its original range. Federal and state protection and the banning of organochloride pesticides in the United States have helped bring about a recovery in some parts of the species former range. The current estimate of about 500 breeding pairs, a slight increase since the early 1970s, is far less than the estimated historical level of 1,200 pairs.

The resident southern bald eagles population in Everglades National Park, Florida, averaging nesting 52 pairs per year, is believed to be stable. The park population accounts for about 15% of the total Florida population and is one of the largest contiguous populations of southern bald eagles on protected land.

Since the late 1950s potential bald eagle nest sites in the park have been surveyed at least monthly, from October through March. Data on annual adult and subadult populations, nesting attempts, nesting successes, and numbers of young fledged are being compiled and analyzed in order to provide a picture of how a natural top predator population functions.

Prey remains found in and around active eagle nests in the park have been collected intermittently since the early 1960s. In 1989 a systematic collection of prey remains and nest-site descriptions was started. This data will be used not only to better define the ecological role of the southern bald eagle in Everglades National Park, but to identify possible trends in prey selection over time. A suspected deterioration of estuarine productivity in the park, believed due to changes of natural water regimes of upland flow, is thought to have already reduced populations of osprey. Bald eagles are not only fish predators and may have shifted to other kinds of prey.

While other populations of southern bald eagles have suffered drastic declines, the natural stability and protected nature of the park population provides an ideal opportunity to study natural population and reproduction dynamics. This natural population also serves as a species indicator of the environmental health of Everglades National Park.

John Curnutt
Wildlife Biological Technician
Endangered Species Monitoring Project
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Everglades National Park

Battle for Bloody Hill Continues

Towards the beginning of the Civil War southwestern Missouri was the site of a battle of national significance waged to decide if Missouri would remain in the Union. For five hours Confederate and Union soldiers fought for control of a hill overlooking Wilson's Creek. When it was over 2,539 men were killed and the Union retained control of the state. The previously insignificant hill was later named Bloody Hill, and the area surrounding it became Wilson's Creek National Battlefield.

The cannon and musket fire have long been silenced yet a battle still rages on. A battle of different sorts, between different foe, but still of national significance. Researchers and resource managers are trying to hold onto Bloody Hill for a new reason. This time the combatants are plants. The Missouri bladderpod (*Lesquerella filiformis*), a winter annual, is federally listed as endangered by the U.S. Fish and Wildlife Service. Its foe: competition from exotic (alien) and woody species.

Based on a 2-1/2 year study completed in 1989, the results are summarized, as follows:

- Researchers found woody plant removal had no significant effect on short-term survival or overwintering success, but did increase germination rates. A supplementary study of shaded and open microsites indicated that *L. filiformis* plants growing in the shade flowered for a longer period of time and produced more leaves, buds, and pods than did plants growing in the open. This appears contradictory to the plants usual preference for open habitats and may be partially explained by the fact that this research was conducted during an extreme drought cycle.

- Exotic weeds, particularly three species of annual *Bromus*, were found to dominate the glades. Field results examining competitive interaction were inconclusive, while greenhouse results suggest that *Bromus* does interfere with the survival and vigor of *L. filiformis*.

- Late summer fires had no significant short-term effect on the populations; however, spring fire significantly lowered survival. Moderate and high levels of trampling were also found to reduce survival, which is important since Bloody Hill is also a visitor use area.

This information helped researchers to compile a list of management recommendations that may be used by the staff at Wilson's Creek to continue the battle for Bloody Hill. These recommendations are as follows:

- Control weedy exotics in the glades. Use prescribed spring fire to control annual exotic plants on areas of glades that do not currently support *Lesquerella*. Use weedeaters to mow *Bromus* (before seed set) in areas where *Lesquerella* is currently found.

- Create, finally, a vegetational buffer zone around populations to discourage exotic species encroachment.

- Stop encroachment of woody species into *L. filiformis* habitat; in some cases, reduce existing woody cover by removing trees. Cut and treat stumps of woody growth in the vicinity of *L. filiformis*. Use late summer prescribed fire, after woody plant removal, to maintain open glades.

- Limit visitor damage to *L. filiformis* habitat by reducing areas impacted by abandoned and existing trails and minimize disturbance caused by management actions.

- Introduce *L. filiformis* to glades or parts of glades that, through appropriate management, have become characteristic *Lesquerella* habitat.

- Establish populations that are sustainable without intensive management, that can resist invasion of exotic competitors, and whose functional integrity is maintained by the associated biotic community.

- Monitor the glade community in general, dominant exotics in particular, and *Lesquerella filiformis*.

This battle of Wilson's Creek is much longer than the first, no blood is shed, and no lives of men lost. The battle is fought over survival of a species, not survival of a Nation. Biological diversity is now at stake. With the help of researchers providing specific management recommendations to park managers, this battle can also be won. Lisa Potter Thomas, Research Associate, and James R. Jackson, Professor of Biology, Biology Department, Missouri Southern State College, conducted the research for this project.

Gary Sullivan
Biological Technician
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Midwest Regional Office

Florida Panther Research in Big Cypress

South Florida is the last stronghold of the Florida panther, with 570,000 acres of panther range within the boundaries of Big Cypress National Preserve. Yet, recent survey work indicates that no resident population of panthers is there.

In 1989, the National Park Service initiated research to determine the status of the panther in Big Cypress. For the past two years, the drying swamp buggy trails offered excellent substrate for tracking. Searches from January to March revealed abundant sign of deer, hogs, bobcats, alligators, raccoons, and even bears. Better than human trackers were the specially trained "lion dogs" that scented for panthers for 50 days each year in the roadless areas of the preserve.

The combined intensive effort netted only one panther each year that was fitted with a radio transmitter. Even more disconcerting has been the fact that neither cat has remained in the preserve. One moved to adjacent private lands; the other moved east into the adjacent Water Conservation Areas.

Although data are sparse, indications show that disturbance, possibly caused by dogs and/or offroad vehicle use, may hinder the panthers' use of the preserve.

One of the panthers that had been radio-collared in Everglades National Park moved into the Big Cypress during the summer 1989. On the opening weekend of the fall General Gun Season, he was inadvertently treed by some hunter's deer dogs. That night he left the area and traveled back to the park. Research in other study areas in Florida is showing similar impacts on panthers due to disturbance associated with hunting. If indeed the level of hunting in Big Cypress, that is, 177 days in which hunters can be in the woods with a weapon, is not compatible with panther use of the area, a remedy must be found.

The enabling legislation provides for perpetuation of the natural resources while at the same time providing for traditional recreational use. The management challenge is to regulate hunting to the degree that will provide both a quality hunt for area users and a satisfactory environment for panthers.

Deborah Jansen
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Big Cypress National Preserve

Florida Panthers and White-tailed Deer in Eastern Everglades

In October 1986 and January 1987, companion studies of Florida panther (*Felis concolor coryi*) and white-tailed deer (*Odocoileus virginianus seminolus*) were initiated in eastern Everglades National Park. Six panthers were captured and radio-tagged by early 1987, including two adult females and the twin kittens of each; in addition, a young adult female was radio-tagged in April 1988. By September 1989, 68 white-tailed deer had been captured; 58 of these were equipped with radio transmitters.

At the end of 1989, preliminary observations indicated that the distribution of Florida panthers may be related to sex, reproductive status, distribution of deer, and hydrologic cycles. Breeding females have exhibited stable, insular ranges that overlap in the Long Pine Key/Hole-in-the-Donut area; they appear to rely primarily on white-tailed deer as prey, particularly when pregnant or accompanied by kittens, and concentrate their activities at forest and hammock edges where they typically kill deer. Immature panthers have dispersed to the edges of their natal ranges and beyond into unprotected peripheral habitats where they use small prey such as raccoons and rabbits. In the wet season, panthers noticeably reduce their range, concentrating activity at high elevations. On the contrary, ranges of white-tailed deer in the wet season are equal to (females) or larger than (males) those in the dry season. Estimates of density, natality, mortality, and home range indicate that the white-tailed deer population is relatively stable and closely tracks a system with low, stable primary productivity.

Given the finite size of protected habitat east of Shark River Slough where white-tailed occur, the potential population of Florida panthers in eastern Everglades appears to be inherently low. We believe that at best a panther population of 8 to 10 individuals, including no more than 3 or 4 breeding females can be expected to occupy eastern Everglades National Park and adjacent areas.

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Everglades National Park
and
Tommy R. Smith
University of Florida at Gainesville

Desert Pupfish Habitat Improvement Project

Quitobaquito Springs/Pond are located in the southwestern portion of Organ Pipe Cactus National Monument, Arizona, adjacent to the U.S./Mexico International Border. An endangered, endemic pupfish (*Cyprinodon macularius eremus)* inhabits the spring outflows and the pond at Quitobaquito. Two springs, located to the north of the pond, provide the water for the pond.

Historically, an open ditch fed water from the springs to the pond. Both the ditch and the pond are man-made, and were created in the mid-1800s. Vegetation growth in the open ditch channel was controlled by the presence of livestock grazing. In 1962, the Quitobaquito area was fenced off to prevent livestock grazing, which favored the general health of the natural resources, but increased the maintenance workload in order to provide adequate water flow from the springs to the pond. From 1962-68, approximately 10 permanent and seasonal maintenance staff cleaned, by hand, approximately 500 feet of open ditch yearly.

In 1968, due primarily to a reduction in staff, a pipeline replaced approximately 400 feet of the ditch, unfortunately reducing the water-based habitat for wildlife that had historically existed. This action effectively reduced pupfish habitat, which in natural environmental conditions is usually stream-based. In addition, the remaining sections of open ditch and the spring heads continued to become clogged with vegetation, twice reducing pond water levels within a one-week period by as much as 15-18 inches, exposing critical pupfish habitat areas to blue sky.

In 1989, a project designed to improve the habitat for the endangered pupfish was completed. This project involved installing an open concrete-lined, natural-looking channel, maintaining the existing pipeline as a backup system, improving the spring heads, and enhancing the riparian habitat. The channel was based on a successful 50-foot test channel designed and installed in 1985. A series of pools were located along the channel, with overhangs designed to provide additional habitat for the desert pupfish and associated fauna, particularly the Sonoran mud turtle (*Kinosternon sonoriense longifemorale*). Small amounts of sediment are allowed to accumulate in the channel bottom to emulate natural conditions and to allow for growth of some aquatic vegetation and associated arthropod fauna. Significant vegetation blockage to the channel was eliminated, because of reduced soil substrate required by bulrushes (*Scirpus olneyi*) for growth. In essence, then, the project provides a system requiring minimal maintenance, while still maximizing ecological diversity. The project took a month and a half to complete. When the channel was opened to the pond, pupfish were found throughout the channel within a week and a half. The channel is monitored on a weekly basis and a census of the number of pupfish using the springs, pond, and channel will be conducted in September 1990.

James J. Barnett
Resource Management Specialist
Organ Pipe Cactus National Monument

Rarity of Hawaiian Plant Species: A Case of *Sisyrinchium acre*

The rarity of many endemic Hawaiian plant species is all too often due to obvious causes involving herbivory by feral goats and pigs. Yet other species remain rare even in the absence of feral ungulates due to complex unknown causes. Competitive exclusion by alien (exotic) plant species is often assumed but rarely demonstrated. A simple experiment underway at Haleakala National Park is testing the hypothesis that displacement by alien grasses comprises an important factor in the extreme rarity of *Sisyrinchium acre*, a small, yellow-flowered species endemic to high elevation shrubland of Maui and Hawaii. It is the only native member of the iris family in the Hawaiian Islands. South American species of *Sisyrinchium* are yellow-flowered, and the Hawaiian species may be derived from one of those. North American species of *Sisyrinchium* have blue flowers and are known as blue-eyed grass. The ancient Hawaiians called this species mau'u-ho'ula-ili, meaning "grass which turns the skin red," and used the leaves for tattooing.

The experiment was initiated opportunistically following a project in February 1988 which removed a massive tree fall accumulation near the park entrance at 2,100 m elevation. A planted stand of large alien pine (*Pinus radiata* and *P. pinaster*) trees had been uprooted by hurricane force winds of a storm in January 1980 and had lain in place for eight years. After removal of the dense jumble of pine trees, the ground was completely barren of vegetation. We assumed that alien grasses would quickly occupy the site, but after several months, *Sisyrinchium* seedlings started to appear. This rare plant had obviously germinated from seed stored in the soil, whereas the seed bank of alien grasses had apparently been exhausted by years of lying under the downed pine trees. We marked off plots and tagged individual plants in January 1989, at which time there were over a 100 *Sisyrinchium* plants, more than we had seen otherwise after a decade of field work within Haleakala National Park. Other native species appearing in the area include two sedges, *Carex wahuensis* and *C. macloviana*, the rush *Luzula hawaiiensis*, the rare herb *Gnaphalium sandwichensium*, and the shrubs *Vaccinium reticulatum*, *Sophora chrysophylla*, and *Coprosma montana*.

A 200 m^2 plot was delineated within which all nonnative plants would be removed periodically. Within this plot, there were 76 *Sisyrinchium* plants in January 1989 and 376 a year later; native plants now cover about 10% of the area, with *Sisyrinchium* contributing half of this cover. In an unweeded 70 m^2 plot nearby, there were 49 *Sisyrinchium* plants in January 1989 and 56 a year later, by which time alien grasses and forbs covered 90% of the area; a large percentage of the *Sisyrinchium* individuals were in various stages of being overtopped by rapidly growing grasses, especially velvetgrass (*Holcus lanatus*). In November-December 1989, an additional 200 individuals scattered throughout the area of pine removal were marked to ensure a sufficiently large sample size for evaluating the impact of alien grasses on the *Sisyrinchium* population.

Only time will tell but based on observations to date we anticipate that *Sisyrinchium* will gradually be eliminated outside the managed plot, but will continue to thrive where competing alien weeds are removed. With a better understanding of factors contributing to rarity of *Sisyrinchium* and other rare Hawaiian species, we can devise appropriate management strategies.

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Research Scientist
and
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Fame Flower Research of Midwest Endemic Plant

About 8,000 years ago, many plant species migrated eastward through what is known as the prairie peninsula. This migration was in response to warmer and/or drier climatic conditions. One such species, fame flower, or *Talinum rugospermum* Holsinger, is endemic to savannas, prairies, and sandstone/basalt outcrops of the Midwest, although outlier populations exist in Texas, Kansas, and Nebraska. This small succulent herb is also known as "flower of an hour" because each diminutive pink flower is open for a few hours only, late in the day. Today, fame flower is a candidate for federal listing as threatened and is state endangered in Iowa, Indiana, and Minnesota and is unlisted in Wisconsin and Illinois. Respectively, five and one population(s) are known from Saint Croix National Scenic Riverway and Indiana Dunes National Lakeshore.

In 1986, research was initiated to characterize the population biology and ecology of this species and to identify its natural habitat. Fame flower grows in disturbed areas, with many of the Indiana populations found along roads and trails where anthropogenic disturbance has maintained an open habitat. In adjacent natural vegetation, landscape fragmentation has resulted in population extirpation or reduction by disrupting natural processes. Natural fire disruption and human suppression of fires has led to tree canopy closure and buildup of thick litter at many sites in Indiana. Any subsequent fires are likely to be very intense and kill fame flower plants, if the shading has not already eliminated them. Small disturbance patches in dry prairies and sand savannas are fame flower's natural habitat. What creates these small disturbances is unclear, but possibilities include fire, drought, and/or activity of ants, moles, pocket gophers, and other small mammals.

One goal of the research is to understand how fame flower can persist in a temporally and spatially variable environment. Factors that can promote population persistence include presence of a persistent seed bank, differential sensitivity of life cycle stages (seedlings, juveniles, and adults) to abiotic and biotic impacts, and refuges. Experimental work has shown that seedling emergence, survival, and performance is a function of precipitation amount and habitat. Further work will quantify the effects of fire on adult survival and the differential sensitivity of life cycle stages to precipitation. By understanding how fame flower can persist in a heterogeneous savanna/prairie environment we will be able to recover and restore populations of fame flower by maintaining and recreating its natural community and ecosystem processes. In striving for this community and ecosystem level goal, the National Park Service and other conservation agencies will be able to maintain similar rare plant populations without having to conduct long-term and costly species-specific monitoring.

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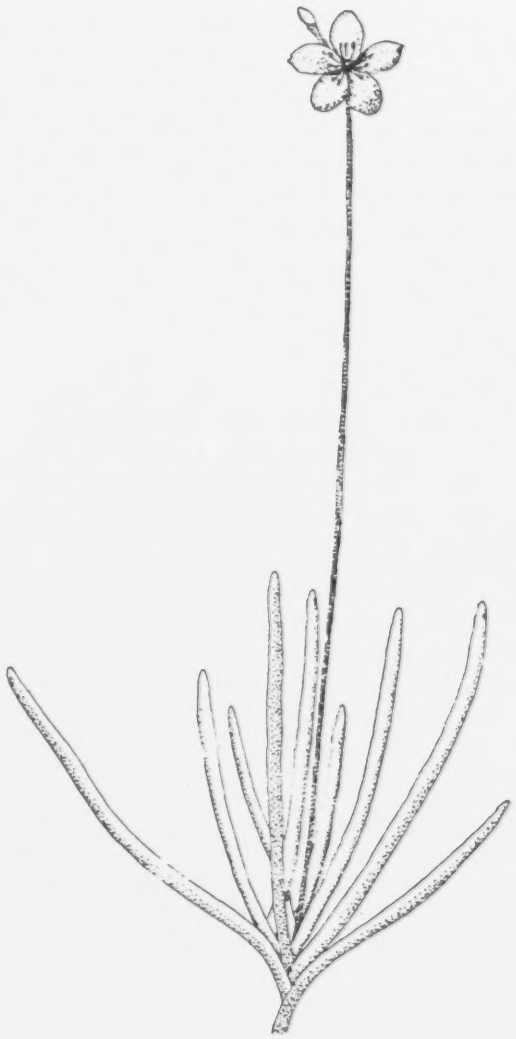


Protecting Nesting Raptors at Pinnacles National Monument

Pinnacles National Monument, California, contains numerous outcrops and walls used by cliff nesting birds of prey. A dozen or more prairie falcon pairs may annually fledge young within the smallish confines of the monument (17,000 acres). Preserving the integrity of the nesting habitat of this species is critical to their continued presence at the monument.

These same walls and outcrops also attract park users. Hikers, boulderers, and technical rock climbers who enter occupied areas may interrupt courtship and mating activity, disturb incubation, or interfere with feeding and food exchange. The net result can be failed, mistimed, or suboptimized nest location and establishment, reduced egg viability, nest abandonment, and/or increased fledgling mortality.

In an attempt to insolate Pinnacles' cliff nesting raptor species from the kinds of human disturbance known from the literature to impact related species (sustained human activity within the nesting territory and approaching a nest from above it), a management program has been implemented. Specific management actions are founded upon information from an annual nesting raptor monitoring program.

The monitoring program has verified that, in large part, Pinnacles' prairie falcons nest upon the same rock formations each year. Thus, those formations that harbor successful nests during the previous season are closed to offtrail visitor use as the prairie falcons return to the monument in early winter (about January 1). Monitors then observe these and other formations to document the locations of courtship, territorial defense, and nest establishment. Monitoring throughout this nest establishment period (January 1-April 15) allows other formations frequented by prairie falcons (or other sensitive species such as golden eagles) to be added to the protective closure list. Once nest establishment is essentially finalized and incubation is begun, unoccupied formations previously closed because of the presence of within year nesting behavior or the occurrence of a successful nest during the previous year are reopened to visitor use. Continuous real-time monitoring throughout the nest establishment period permits a management system that insulates cliff nesting raptors from human disturbance while minimizing restrictions upon park use (the most likely alternative management strategy would be to close all potential nesting habitat to offtrail use during the entire nest establishment season).

Periodic monitoring continues through the spring to document fledgling success. This information provides an index of the "health" of the prairie falcon population. The monitoring program has permitted informed decisions to be made on related projects. For example, the opportunity to reintroduce the peregrine falcon into the monument occurred in 1989. Four years of monitoring data were used to select a historically successful and otherwise optimal cross-fostering site. Additionally, two 1989 prairie nests in which eggs were successfully produced but did not hatch were discovered. The eggs were collected for analysis (not yet complete). Without the monitoring program we would not have known of this failure or would not have had the opportunity to gain insight into its cause(s).

Monitoring the response of prairie falcons to trail users has identified a possible need for additional management action. Incubation is often interrupted when people stop to rest or frolic on trails near nests. It may be necessary to establish on trail "pass through" zones near nests to mitigate these influences.

The raptor nesting monitoring program at Pinnacles provides the information to maximize the potential for this species' long-term presence at the monument. Additionally, it has provided information that can be used to make informed decisions on related projects, and has surfaced new and relevant considerations that will improve the raptor protection management program. Parallel monitoring programs should be extended on an ecosystemwide basis.

Steve DeBenedetti
Chief, Division of Resource Management
Pinnacles National Monument

Yellowstone's 1989 Wolf Study

In 1988, Congress directed the National Park Service and the U.S. Fish and Wildlife Service to study four questions concerning the proposed wolf recovery into Yellowstone National Park:

1. How would reintroduced wolves be controlled in and out of the park?

2. How would wolves affect big game hunting near the park?

3. How would wolves affect grizzly bears?

4. How would wolf recovery zones be designated?

To answer these questions, the agencies conducted 10 separate studies in a multifaceted approach involving (1) computer simulations, (2) extensive literature reviews, and (3) opinions of 30 North American and Eurasian wolf, grizzly bear, and ungulate experts. The report containing the 10 technical studies was released to the public in May 1990 by the two agencies.

The studies concluded that wolves were present in Yellowstone National Park at least as long as 1,000 years ago. Wolves were extirpated about 1926, but individual wolves, possibly from Canada, are reported now and then, but not confirmed. Wolves could possibly return to Yellowstone by natural recolonization, although this is unlikely. Alternately, federal legislation could direct reintroduction, or wolves could be restored as an experimental population under Section 10(j) of the Endangered Species Act of 1973.

During the period from 1980 to 1988, Yellowstone National Park contained an average of 37,800 ungulates during summer, and 23,100 ungulates during winter. Many ungulates migrate from the park's high plateaus each fall and early winter and some of those leave the park. Elk constitute 74% of the winter ungulate biomass available to wolves and 82% of the summer biomass. For every 100 elk on Yellowstone's northern range during winter there are 10 mule deer, 3 bison, 2 pronghorn, 1 bighorn sheep, and 1 moose. Bison slightly outnumber elk (95 elk for every 100 bison) on the park's interior winter ranges.

Spatial-temporal densities of ungulates resulted in models suggesting that about 75 wolves in 7-9 packs might be supported on the northern winter range, and about 140 wolves in 11-14 packs might be supported parkwide. If these estimates proved correct, ungulate to wolf ratios would be 270 ungulates per wolf during summer, and 200 ungulates per wolf during winter. Wolf densities and ungulates biomass available per wolf on the northern range would be amongst the highest ever recorded. One computer simulation indicated elk populations would decline 15-25% after wolf recovery, another simulation indicated less than a 10% decline. No ungulate population should be extirpated or reduced substantially. Several park ungulate populations may produce at a higher rate and may be characterized by a lower mean age.

Predicted effects on big game hunting range from none or minor effects on elk harvest for most elk herds, to significant curtailment of cow harvest in two other herds that are more heavily harvested.

Visitor activity should be little affected by wolf recovery. Ungulate populations will remain highly visible, a few closures of a few square miles may occur around active dens, but some visitor experiences may be enhanced by seeing or hearing wolves.

Wolves and grizzly (brown) bears coexist in Canada, Alaska, and Eurasia. There should be little impact of wolves on grizzly bear numbers.

A broad range of alternatives for wolf recovery zones is available. Options range from a very large core area where wolves are protected on all federal lands to a very limited core area, such as Yellowstone National Park, with management of wolves outside the park as the prerogative of state wildlife management agencies.

Francis Singer, Research Ecologist
John Varley, Chief, Research Division
Norm Bishop, Research Interpretive Specialist
Research Division
Yellowstone National Park

Monitoring Vegetation Change at Craters of the Moon

Visitors to Craters of the Moon National Monument, Idaho, are typically struck by the barren, seemingly lifeless panorama that engulfs them. No doubt their first thought is that the area is aptly named. Although once a dynamic area (the last volcanic eruptions probably occurred about 2,000 years ago), to the casual observer little, if any, ecological or geological change seems to be now taking place. The landscape and vegetation appear at first glance to be both timeless and stable. Indeed, early ecological research on plant succession on the younger lava flows supported this viewpoint.

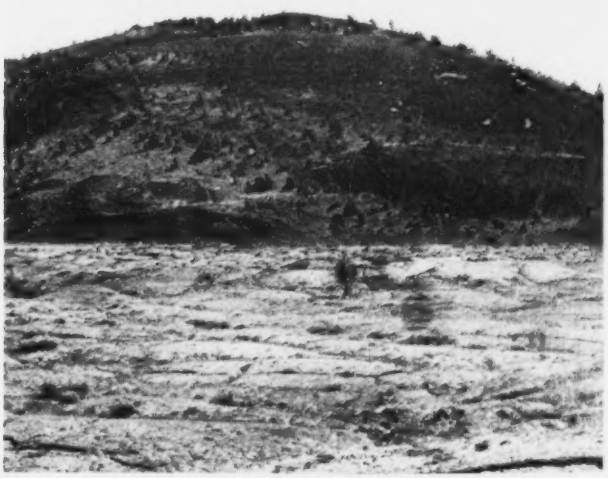
Things are not, however, always as they appear. Recent changes in the densities of one of the major plant species, limber pine, on the numerous cinder cones of the monument have been dramatic. Increases in the densities of limber pine of up to 4% a year in some areas have been documented in a study by the Cooperative Park Studies Unit (CPSU) at the University of Idaho (UI) which is examining vegetation change in the monument.

This study was prompted by the discovery of a detailed set of old photographs taken by Robert Limbert during his 1922 exploration of the area. The sites of the original photos were located, which permitted retaking of an exact duplicate of Limbert's photos. These sites have become part of a network of permanent photo points being established in the monument. Comparative photographs taken at different times provide one of the easiest, and, in many ways, one of the most exciting and rewarding ways to monitor ecological change. The UI study has since been involved in an extensive search for other old photos which will allow the monitoring effort to be expanded. This, in itself, is a rewarding endeavor. It is always amazing how much old photo documentation is available on National Park System areas, even those as isolated as Craters of the Moon.

We hope to publish a complete report of this work by the end of the year. We also hope to incorporate our results into the park's interpretive program to help explain the concept of global ecological change. Our belief is that the visiting public does not give much thought to the fact that ecosystems change. We hope to make this point clearer by illustrating that change does occur, even in the seemingly timeless landscape of Craters.

Gerald Wright
Research Biologist
NPS Cooperative Park Studies Unit
University of Idaho at Moscow

1922 Photograph by Robert Limbert



1988 Photograph by Gerald Wright

Monitoring Protects Critical Water Resources

The National Park Service, the state of Nevada, and Bond Gold, Inc. (BOND), are establishing a ground water monitoring program in the Amargosa Valley, which is adjacent to Death Valley National Park. The monitoring program is required under terms of a state permit to BOND to withdraw 2,000 gpm of ground water for 10 years as part of its mining operations. The monitoring is to ensure that the ground water and spring resources at Death Valley are not impacted by nearby ground water pumping. Specifically, NPS concerns are for the potential depletion or cessation of spring flow in Death Valley.

Springs are the only water supplies of acceptable quality for wildlife and human consumption. Major Death Valley springs issue at elevations ranging from about 950 to 1,800 feet below Amargosa Valley water levels, separated from the Amargosa Desert by the Funeral Mountain Range. The source of spring flow is not fully understood due to complex geology; however, interbasin flow from the Amargosa Desert is hypothesized.

To provide a forewarning of potential impacts to Death Valley, the state engineer conditioned BOND's application by requiring a ground water monitoring program in the Amargosa Desert to be implemented in conjunction with an NPS spring flow monitoring program in Death Valley. The proposed BOND program used existing wells. The drilling of three additional wells was requested by the National Park Service to provide a more comprehensive network.

One of the new wells was designed to test the concept of possible interbasin flow by fractures/fault planes in the Funeral Mountains. BOND agreed to the monitoring condition. The deep test well, drilled in consolidated quartzite, encountered first water at about 955 foot depth. Major water was encountered about 1,085 foot depth. The well was drilled to 1,111 feet, with a static water level of 935 feet. Large fractures were recorded by a newly developed ultrasonic bore hole probe. Sixty gallons per minute were pumped during a well test with only 2 foot of drawdown. This new information supports the concept of interbasin flow and suggests that ground water pumping in the Amargosa Desert may affect movement of ground water to Death Valley.

The monitoring program was activated in September 1989. If indicated, modifications will be made in the ground water pumping to protect the Death Valley water resources.

William Werrell
Hydrologist
Water Operations Branch
Water Resources Division

Water Quality Research at Great Basin National Park

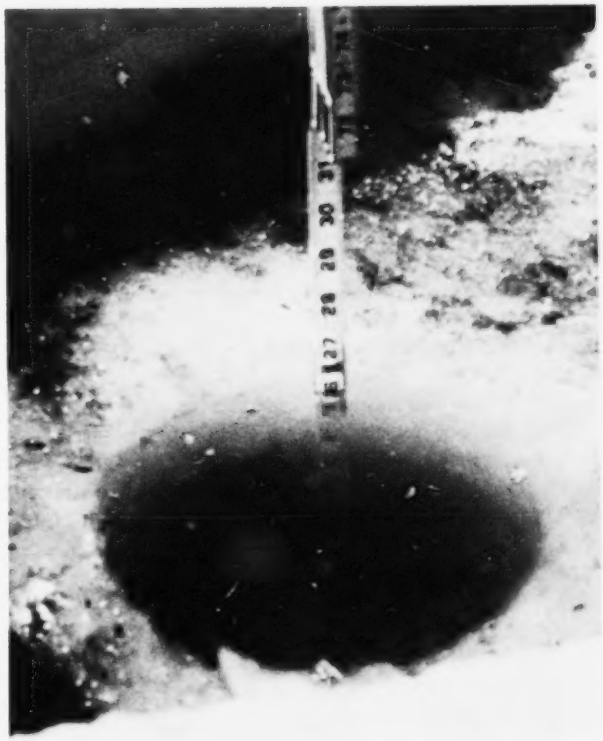
The Great Basin in Nevada is named for the fact that water which falls in this physiographic province flows to no ocean, but rather makes its way to the valley floors where it percolates into the alluvium to recharge the basin aquifers. But here, as with all arid regions, water is precious and demands on it are many. Whether in support of natural systems or providing for visitor use, water is a critical resource and protecting the quality of the water at Great Basin National Park is a paramount concern.

Six alpine lakes are in the park. Preliminary water chemistry analyses conducted in 1988 by scientists at the Environmental Protection Agency's (EPA) Environmental Monitoring Systems Laboratory in Las Vegas, Nevada, indicated that the water quality of two lakes (Stella and Teresa) may be some of the purest in the continental United States. But these lakes are susceptible to man-caused acidification. With the potential development of two coal-fired power plants in the park's vicinity, baseline information on the fragile water quality of these lakes could prove to be extremely important, especially relating to the threat of acid deposition.

Additional water quality analyses were needed to identify sensitive waters and provide a baseline from which to measure future degradation and initiate protective action. In 1989, representative streams and lakes in the park were sampled and analyzed for water quality parameters using state-of-the-art procedures at the Environmental Monitoring Systems Laboratory. Laboratory analytical determinations of conductivity, Ph, dissolved inorganic carbon, dissolved organic carbon, acid neutralizing capacity, Ag, Al, As, Ba, Be, Ca, Cd, Cl, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, No3, Pb, Sb, Se, So4, Ti, and V were measured with quality assurance procedures. None of the six lakes in the park were considered to be acidified in 1989. However, all six lakes and streams were deemed to be acid sensitive, according to the classification criteria of the EPA's National Surface Water Survey.

With the baseline established, a simple linear regression between conductivity and ANC (acid neutralizing capacity) was derived. This relation will allow inexpensive estimates of lake and stream ANC by conductivity measurements taken in the spring and autumn of each year. Combined with quality assured Ph data, semiannual conductivity surveys of representative lakes and streams should provide a simple and practical strategy for triggering intensive chemical monitoring if a threat occurs.

Mac Brock
Resource Management Specialist
Great Basin National Park



Cave Restoration

How long did it take to make this cave? This innocent question from a visitor emphasized the condition of Oregon Cave until recently. In the 1930s, workers blasted tunnels, enlarged passages, and stashed rocks and trash in side passages. The cave was so modified that it looked more like a man-made tunnel than a natural cave. Man-caused organics also affected the cave. Most obvious were the algae and moss that grew near the lights. Less obvious were skin flakes and clothing lint from human visitors and the leaching of asphalt from the trail. All these organics threatened to dissolve cave formations and reduce the diversity of cave communities.

To restore the cave to a more natural state, the National Park Service in 1989 removed lint, trash, asphalt, and algae, as well as 80 cubic yards of construction rubble, restoring over 1,300 square feet of cave surface. Crystal clear water once again cascades over white marble, unrestrained by rubble or culverts. Thousands of formations were uncovered, including undisturbed dendritic clay patterns on walls--called vermiculations. These "virgin" formations will help determine which vermiculations alongside the trail in other parts of the cave are natural and which ones are man-caused.

Monitoring and research helped to ensure that restoration did not further damage the cave. Differences between man-disturbed and undisturbed sediments were identified so that no natural cave fill was disturbed. There was concern that spraying the algae with bleach would affect the cave stream but water quality remained good.

Monitoring of temperature, humidity, and evaporation rates in the cave has been continuous for most of the past year. Recent monitoring, combined with historical records, has clarified which natural entrances have been modified and how many airlocks are needed to restore prehistoric airflow patterns in the cave.

Rubble removal will continue until 1992. Then a new trail and lighting system will be installed. The new trail will trap lint and other man-caused organics and ease their removal from the cave. The design of the lighting system will reduce man-caused evaporation, maintenance impacts, and algae growth.

John E. Roth
Park Ranger
Oregon Caves National Monument

Spring Flow Trends at Pipe Spring

Since 1977 spring yields at Pipe Spring National Monument, Arizona, have declined on the average of 2 gpm per year. If this rate of decline continues, the springs will cease to flow by the mid-1990s. Investigations concluded that the causes of declining spring flows were not natural, but were probably the result of large-scale ground water pumping in the area. A U.S. Department of the Interior, Bureau of Indian Affairs, study was conducted in 1976 of the hydrology of the Kaibab Paiute Indian Reservation surrounding the monument. This study predicted that pumping from the fractured Navajo Sandstone along the west side of the Sevier Fault near the town of Moccasin could be expected to decrease flow on area springs. A recently proposed waste incineration plant nearby has increased management concerns on the condition of the aquifer supplying the historic springs in the monument.

A monitoring study is evaluating spring flow trends. Ground water and spring flow data from the monument and vicinity from 1977 to 1989 indicate that total spring flow has steadily declined, while 2 and 4 miles outside of the monument, respectively, ground water levels and spring flow appear to remain stable. Regional ground water withdrawals have not been ruled out as the cause of declining spring flows, but two factors suggest that local physical changes in spring characteristics may account for at least part of the recent trends observed in spring flows at Pipe Spring. First, of the four springs which comprise Pipe Spring, two are experiencing significant declines in yield; one appears to remain stable and one, the highest elevation of the four springs, is actually experiencing a gradual increase in yield. Secondly, a new monitoring well, completed in 1989, suggests that the aquifer supplying Pipe Spring is artesian, whereas the aquifer 2 miles closer to the probable recharge area is reported to be watertable conditions.

This information indicates that the aquifer is more complex than originally perceived, but monitoring spring flow trends has improved our understanding of the ground water system supplying Pipe Spring. While it is suspected that ground water at each location is a single aquifer, it has not been possible to document regional aquifer declines or to demonstrate the nature of the interconnection. The monitoring project and the new monitoring well will provide information for substantive management recommendations.

Richard Inglis
Hydrologist
Water Operations Branch
Water Resources Division

Oil and Gas Management in National Park System Units

Wait a minute! Is this the Bureau of Land Management? When the National Park Service says natural resource surveys, we don't mean oil wells! Or do we?

In 1989 the Mining and Minerals Branch and the 11 parks that have active oil and gas operations completed a three-year project that inventoried over 1,000 wells within park boundaries. The surveys located the wells, described the condition of the equipment, and identified the owners and operators. The inspections found that the quality of operations inside units ranges from high quality, well-maintained operations to sites that are leaking oil or gas, trashy, aesthetically intrusive, and safety hazards. Many operations are damaging natural resources, for example, erosion of topsoil from access roads or pads, or contamination of soils.

As a result of the information gained from the inventory, the parks are now working to improve the quality of active operations and get old wells properly plugged and the sites reclaimed. For example, Padre Island National Seashore, Texas, worked with an operator to get an additional tank installed at a production facility to contain condensate, a kerosene-type petroleum product, that had been dumped into an open pit. Currently, they are working to get the pit cleaned out. Big South Fork National River and Recreation Area is negotiating with the Tennessee Oil and Gas Board to get more stringent enforcement of state laws. Cooperation with the states is important for all the parks with oil and gas operations, since over half of the wells in the parks are not controlled by NPS regulations.

Inventory information on operator changes has allowed Lake Meredith Recreation Area, Texas, to secure plans of operations for over 50 wells. The plans are contracts with operators to stipulate how the sites will be maintained, provide emergency procedures for spills, and most importantly, provide a bond which ensures that the well will be plugged and the site reclaimed when production ceases.

Operators have plugged at least five wells as a result of the plans. At Lake Meredith, Colorado Interstate Gas plugged a gas well located in the middle of the Canadian River after the park requested that the well be plugged or substantially modified to withstand floodwaters and debris. Mobil Oil plugged four wells in Big Thicket National Preserve, Texas, after the park found the wells on their lease and requested a plan of operations. Cuyahoga Valley National Recreation Area, Ohio, has budgeted $150,000 to plug and reclaim nine wells on federal property.

Oil and gas may not be considered a natural resource by the National Park Service, but the wells affect NPS-protected resources. Identification and description of the operations is an integral part of the baseline data that parks with operations must have.

Leslie Vaculik
Petroleum Engineer
Mining and Minerals Branch

Findings From Ecological Research Program

The high elevation lakes and streams of Rocky Mountain National Park, Colorado, are some of the most vulnerable in the world to change caused by acidic atmospheric deposition. Alpine and subalpine lakes are surrounded by steep rocky slopes that supply little neutralizing capacity to prevent acidic rain or snow from changing aquatic environments and the pristine biotic communities which inhabit them.

Loss of ecosystem integrity from acidic deposition is not as immediate a threat to the park as was thought several years ago, but is still a very real possibility. In 1981, our concerns over increasing sources of air pollutants, which could cause acid rain to fall on the park, prompted initiation of a long-term ecological research and monitoring program in Loch Vale watershed. Potential sources for acidic deposition included oil shale development west of the park, unrestricted urban and industrial growth east of the park, refining of metal ores to the southwest and in northern Mexico, and long-range transport of polluted air from California. Our goals in the Loch Vale watershed project have been to explore the sources and seasonality of acidic deposition and to examine just what the consequences could be to fragile aquatic ecosystems.

We have found that precipitation falling on Loch Vale watershed is acidic in the summertime. Eighty-five percent of annual moisture to the watershed falls as winter snow; however, this precipitation is not acidic, although it contains small amounts of pollutants. The snowmelt each spring dominates the annual hydrologic and water quality cycle through mountain lakes and streams. From a fish's viewpoint this means that aquatic systems are as clean as ever.

Rocky Mountain's clean precipitation results from winter snows originating in the northern Pacific Ocean and passing rapidly over undeveloped areas of the western United States. Rocky's acidic precipitation is caused by monsoon rains flowing over the Southwest United States and combining with air from the metropolitan areas to the east. Possible changes in the climate as we enter an era of global change include varying the proportions of moisture from these sources. And one important consequence of a major shift in precipitation patterns may be acidification of Rocky Mountain aquatic ecosystems. Continued growth of the Denver urban area, development of a large oil shale industry, and unrestricted smelting of metal ores in northern Mexico could additionally increase regional air pollution, increasing the amount of acidic deposition.

Monitoring of precipitation and water quality will continue into the foreseeable future. Annual assessment of the results by research scientists and managers working together will ensure we are not "surprised" by increasingly acid rainfalls.

Jill Baron
Research Ecologist
Applied Research Branch
Water Resources Division

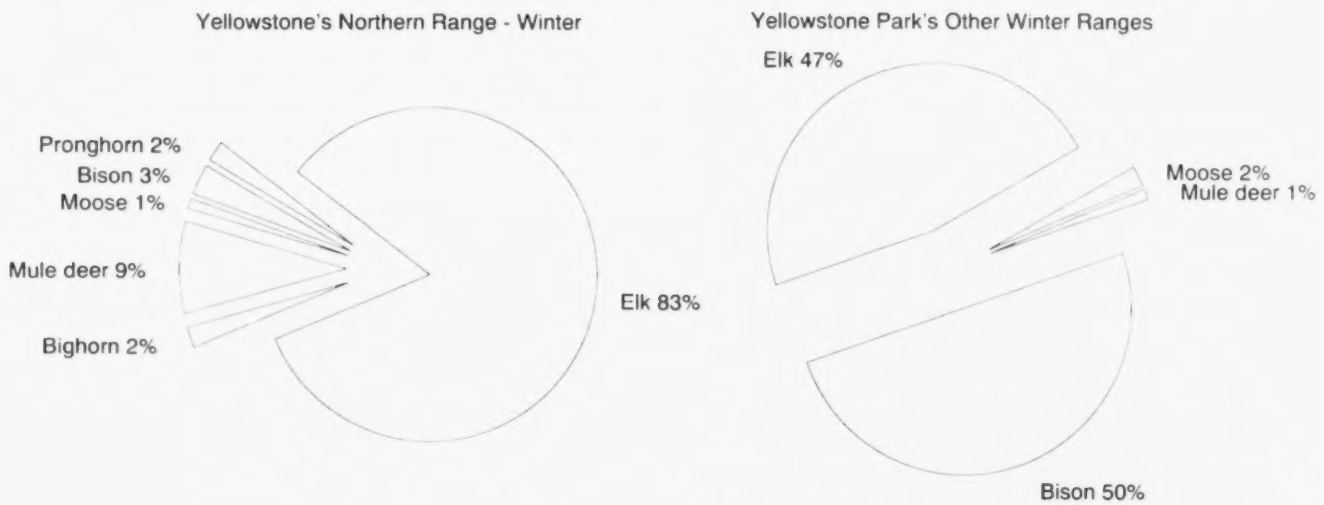
Fires of 1988 and Yellowstone National Park's Ungulates

In August and September 1988, unprecedented drought, lightning, and dry, windy conditions combined to burn approximately one-quarter of Yellowstone National Park. The park's high plateaus typically burn on 300-400 year cycles. The park's northern winter range, where most of the park's seven species of ungulates spend the winter, is more flammable, but no significant burning had occurred there during the 20th century. Over a third of the northern range burned in the fires of 1988. The Research Division of Yellowstone National Park embarked in 1989 on a five-year effort to document the effects of the fires on the park's ungulates, particularly the two species most likely to be affected, elk and moose.

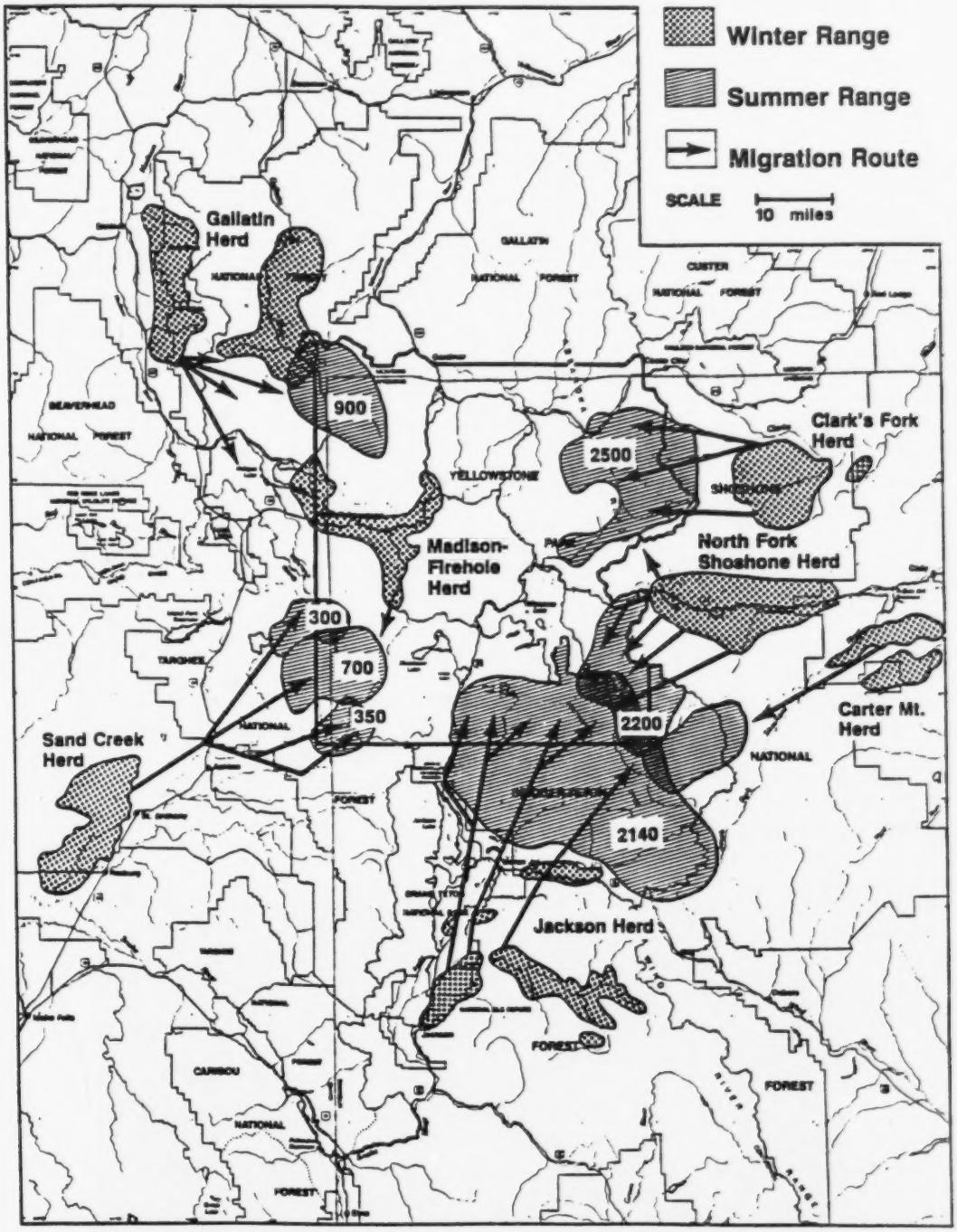
Managing Yellowstone's elk populations has been controversial throughout most of this century. Park staff artificially reduced elk from the 1930s to 1967, but since then have managed elk with a hands-off or natural regulation philosophy. The northern Yellowstone elk herd reached an all time recorded high of 19,000 elk just prior to the events of 1988.

A total of 246 elk were killed by the fires, or only about 1% of the estimated population. Winterkill after the fires was high, about 24% for the northern herd and about 50% for the Madison-Firehole herd, but the drought effects and severe winter contributed to the winterkill. Elk calf weights and calf survival were reduced for calves born during the spring 1990. However, elk condition, calf recruitment, and ultimately elk population size are predicted to increase in the years following the fires. Forage production, protein content, bite sizes of forages, and foraging efficiency are all predicted to increase. The magnitude of the population increase by elk cannot be accurately predicted. Some scientific evidence suggests that forage enhancement from burning may be relatively minor and short-lived. Other evidence suggests that the large-scale, hot fires of 1988 will more substantially enhance elk range. A goal of the research program is to develop a computer model that will predict the effects of the fires on elk carrying capacity in relation to observed climatic conditions.

Francis Singer
Research Ecologist
and
John Varley
Chief, Research Division
Yellowstone National Park



Relative abundance of ungulates on Yellowstone's northern winter range (n = 18,555 ungulates) and other park winter ranges (n = 4,530 ungulates) (Madison-Firehole/Mary Mountain, Thorofare, Pelican, Gallatin) based upon counts, 1980-1988.



Map showing the approximate winter ranges and summering areas for 7 elk herds other than the northern herd which uses Yellowstone National Park. Approximate numbers of summering elk within Yellowstone Park are included.

Inventory and Monitoring in Lake Chelan: A GIS Approach

Stehekin Valley is a classic U-shaped glacial valley, with a meandering river and steep-sided streams with alluvial fans. Vegetation is mixed conifer characteristic of the east side of the Cascades. As the largest (2,500 hectares) valley in the Lake Chelan National Recreation Area, Washington, the valley is extremely important to wildlife, with frequent observations of black bear and mountain lion. The valley is accessible only by foot, boat, or plane and has a history of human habitation since the turn of the century. Currently, 500 acres of private land exist, with approximately 70 year-round occupants; summer occupancy is over 300. Potential development of 200 to 250 homes could occur.

In 1988 and 1989, the North Cascades National Park Service Complex received funding from the inventory and monitoring (I&M) initiative, and with the CPSU at the University of Idaho focused the effort on (1) developing a base map for the Stehekin Valley, (2) assessing the database for the area, (3) developing a conceptual model for the drainage, and (4) planning a workshop on future I&M efforts.

The boundaries of the project were limited to the Stehekin Valley. The only map that existed was the 1:24,000 USGS quadrangle, inadequate to use as a basemap. In addition, the Stehekin Valley had neither vertical nor horizontal control benchmarks from which to survey and plot data. Without the benchmarks, theme data could not be geographically referenced; therefore, the decision was made to bring in the required survey control. Due to the extreme remoteness of the valley and distance to the nearest benchmark (5 air miles), the Global Positioning System (GPS) was used to set eight new benchmarks from the GPS satellites. This required two weeks of field surveying plus extensive helicopter time to access remote reference points. These eight new benchmarks now have horizontal and vertical control to within +/-1 cm. With the benchmarks premarked, true color (1:7200) and black and white (1:24,000) aerial photos were flown. A 1:7200 basemap was then produced in the form of an Ortho-image photomap with State Plane and UTM grid. A Digital Elevation Model, with 10-foot contour intervals, was developed in digital format and mylar overlays produced. The mapping of theme data onto the new basemaps continues as does the data assessment.

The major themes to be incorporated into this spatial database are as follows:

1. property plat maps of the Stehekin Valley
2. roads, trails, campgrounds, hydrology
3. the 100-year floodplain of Stehekin River
4. right-of-ways, pipelines, utility corridors
5. archeological sites
6. classification of vegetation and land use
7. important wildlife habitats

When completed, the information will be incorporated into a park-based geographic information system, allowing park managers to model valley growth over time and assess impacts to natural and cultural resources such as floodplain, archeology, or visitor experience.

Jonathan B. Jarvis
Chief, Resource Management
North Cascades National Park Service Complex

Damaged Ecosystems Get Attention at Channel Islands

Over 140 years of sheep, cattle, and pig grazing, coupled with more recent elk grazing and deer browsing, have left Santa Rosa Island with barren ridges, fouled streams, and "manicured" shrubs. Sheep ate so much of the vegetation of San Miguel Island that in dry years they were seen to be digging out roots to get some nourishment and the island became an 11,000-acre sand pile. In fact every one of the five islands in Channel Islands National Park, California, has been extensively damaged by grazing. This grazing has led to extirpation of native species and a flora of 800 taxa that is 24% alien (i.e, introduced from outside the southern California area).

As the National Park Service has gained management control over these islands, the first resources management priority has been to remove large alien herbivores as soon as possible. This has now been done on Anacapa (the last sheep were removed in the 1930s), San Miguel (sheep were removed in 1966 and donkeys in 1974), and Santa Barbara (rabbits in 1981). On Santa Rosa Island, sheep were removed by the current cattle rancher in the 1940s, and the park has started a pig eradication program this year.

The recovery rate of the plant communities on the islands where grazing has been eliminated is being recorded through a long-term monitoring program (see 1987 Highlights). Our studies show that a very positive pattern is developing in the restoration of native plant communities. In general, simply removing the grazers from an island allows the native shrub species to regenerate. Through time the alien species dominated communities are thereby being replaced by native species dominated communities.

Further, studies are now being conducted to determine the best management strategies for encouraging rare/endemic species. These special populations are in the greatest difficulty because of their restricted distributions and, in many cases, unusually small numbers.

An example of the difficulties is shown in the case of the island oak (*Quercus tomentella*). This highly restricted, island endemic is in a very precarious situation on Santa Rosa Island where alien grazers continue. The small groves are on steep, highly eroded slopes, with most stands having roots either at the surface or up to a one-half meter above it. The ground is continually disturbed and no reproduction has occurred for at least 50 years. Because of this, we have begun to take a more active role in the restoration of this species by putting up enclosure fencing (see photo) around some of the groves and installing erosion control devises. Restoration of this damaged ecosystem is being aided by a close working relationship between all park divisions under the coordination of the island manager and by a strong and brave corps of volunteers.

W. L. Halvorson
Research Biologist
Channel Islands National Park

Don't Eat the Yellow Snow

1990 Isle Royale Wolf Ecology and Prey Relations Progress Report

It had been a long day of following tracks on snowshoes along the Greenstone Ridge searching for large samples of fresh yellow snow. As the sun was setting, the bush pilot radioed to arrange a time for my pick-up so I began tracing my steps back to the frozen harbor. I had collected only eight samples so far that day, so I was paying particular attention to any new sign of moose activity. I noticed fresh wolf tracks on top of my snowshoe tracks which gave me an eery feeling of a second shadow. I also noticed fresh moose tracks and was eagerly tracking this moose for a very fresh urine sample when a loud falsetto howl, originating close by, rang through the air. I felt goose bumps and the hair on the back of my neck bristle when nonrational thought set in (I am 40 miles away from the closest human and I have 8 pounds of fragrant moose urine in my backpack). I choose the nonrational alternative and fled the area as fast as my snowshoes could carry me.

Not all of our yellow snow sampling trips are so exciting. Snow-urine sampling is one aspect of the 32-year-old wolf ecology and prey relations investigations conducted on Isle Royale in Michigan. The objective of the study is to document urine chemistry profiles of island moose and to assess their physiological status during the winters of 1987-88 and 1988-89. The study sampled moose from both the east (boreal conifer) and west (mixed northern hardwood) ends of the island due to the difference in forest types and forage species.

Snow-urine sampling offers an efficient, practical, and hands-off method of assessing the physiological status of large mammal populations. Physiological data provided by the snow-urine sampling compliments the existing use of bone marrow fat content for evaluating nutritional status of moose. This type of sampling may also be more representative of the moose population at large. Physiological data from snow-urine sampling detected severe undernutrition during midwinter in a portion of the moose population that was not suspected based on mortality and bone marrow fat content. Bone marrow fat, collected from dead moose, is the last reserve mobilized during undernutrition and indicates near-exhausted fat reserves and deteriorated condition.

Physiological data from the 1987-88 and 1988-89 winters suggested a more deteriorated nutritional condition in moose that wintered on the east end of the island as compared to the west end. During both winters, moose residing in the conifer forested (east end) regions of Isle Royale had exhausted body fat reserves and showed signs of accelerated catabolism of body protein which are associated with extreme undernutrition and starvation.

The superior condition of moose from the hardwood forests (west end) of the island may be related to the higher quality nutrition associated with the diverse vegetation of the mixed northern hardwood community and lower stem density of balsam fir.

Snow-urine samples will continue to be collected in future winter study investigations and used as an indicator of the winter physiological status of moose on Isle Royale. Determining moose physiological status is critical in assessing one of the three main hypotheses for wolf decline, lack of food. Progress has also been realized this year on the other two hypotheses: disease and lack of genetic variability. An additional three wolves were live-trapped, radio-collared, and blood-sampled for genetic variability. This means that 7 out of the remaining 12 wolves were trapped and blood-sampled. The preliminary results of the genetic analyses of the Isle Royale wolves are expected in early spring.

The 1990 winter field study revealed that 3 pups were born and raised successfully for a total of 15 wolves; 1 adult wolf was attacked and killed in February, by the most established pack, bringing the current count to 14 wolves. The moose population declined by approximately 10% to 1,216 (+ 163) animals.

Our investigation of predator and prey relations continues to broaden in scope and response to ecosystem dynamics and change.

Principal investigators in the study of urinary profiles of Isle Royale moose include Glenn D. DelGiudice, Minneapolis Veterans Administration Medical Center - Research Service; Rolf. O. Peterson, School of Forestry and Wood Products, Michigan Technological University; and Ulysses S. Seal, Department of Biochemistry, University of Minnesota.

Barbara Nelson-Jameson
Resource Management Ranger
Isle Royale National Park

Ozone Air Pollution Threatens Giant Sequoias and Pines in Sequoia and Kings Canyon

Ozone air pollution has been impacting the biological resources of Sequoia and Kings Canyon National Parks, California, since at least the early 1970s. The National Park Service has conducted surveys, plots, and eco-physiological studies of ponderosa and Jeffrey pines in these two parks since the early 1980s. These studies have shown that trees with ozone injury have fewer whorls of needles, have needles with low density, altered physiological processes (photosynthesis, respiration, water use efficiency, light response, and carbon dioxide efficiency), and reduced tree ring growth. Individual trees have only one or two whorls of needles remaining (instead of the normal five for ponderosa and eight for Jeffrey pines) and the last remaining whorls have chlorotic blotches indicative of additional ozone injury (see photo). Crown assessments and growth studies indicate that the parks have some of the most serious ozone injury to ponderosa and Jeffrey pines in the Sierra Nevada.

Pine plots established in 1982 were reevaluated in 1989 and indicated that the number of trees injured (36% in 1982 and 39% in 1989) remained relatively constant during this period. Both plot and survey data indicate that two out of five pine trees have been injured to some degree by ozone. Current studies are addressing the impact that many injured individuals have on the structure of the pine community. In the San Bernardino Mountains, ozone has altered the lower elevation mixed conifer forest because of damage to the ponderosa pines.

Controlled ozone exposures conducted on giant sequoia seedlings in sequoia groves from 1986-1988 have shown that ambient levels of ozone destroy cells within the pine-like needles of giant sequoia seedlings. The visible foliar injury that results is a distinctive chlorotic banding that becomes necrotic and affects most of the needle (see photo on next page). Sequoia seedlings growing naturally in nearby groves also had visible symptoms that were macroscopically and microscopically similar to the symptoms observed on seedlings in chambers. In 1989, lower concentrations of ozone, coupled with drought conditions, resulted in an absence of visible injury symptoms on sequoia seedlings in the groves.

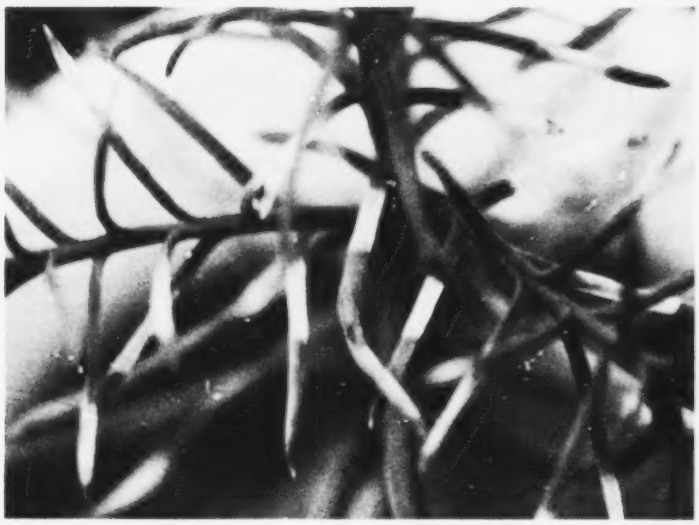
Predictive exposures of giant sequoia seedlings indicate that if current seasonal ozone levels were to increase by 50% (a level found in park units in southern California) that the severity of foliar injury would increase and reductions in root and shoot growth would occur on sensitive individuals. In 1989 field studies determined that individual seedlings were physiologically very different and that sequoia saplings and monarchs also differed physiologically, with monarch sequoias having the lowest physiological rate of all age classes of sequoias.

Controlled exposures of clonal rooted cuttings of some giant sequoia saplings in 1988 to ozone indicate reduced photosynthesis and increased respiration without any visible symptoms when exposed to a 50% increase in ambient ozone. Since the foliage of giant sequoias changes as it ages, going from a pine-needle like stage as a seedling to a scale-like needle (e.g., juniper) as an adult monarch, it can be expected that the older growth stages of sequoias will likely be more tolerant to ozone. However, all species and individuals have a threshold where doses of ozone become toxic and reductions in photosynthesis begin.

Research in the summer of 1990 will begin to examine how much ozone can be tolerated by large saplings before reductions in photosynthesis occur. Research will be initiated by constructing a 100-foot scaffolding into the upper crowns of three sapling sequoias (approximately 140 feet tall) and enclosing branches of the trees with branch fumigation chambers. The chambers will contain carbon-filtered air, concentrations of ozone in the summer air (ambient), and increases of ozone of 50% and 100% above ambient air. Biological responses evaluated will include photosynthesis, respiration, light use efficiency, carbon dioxide use efficiency, chlorophyll concentrations, water relations, foliar nitrogen and carbon levels, and branch growth.

The concern for the monarch sequoias like General Sherman and General Grant is that the large trees have a large living biomass of roots and shoots and grow very slowly. The crowns of these monarchs are often sparse (see photo) and the trees are expected to have a narrow carbon balance, that is, the amount of carbon dioxide fixed by the foliage of monarchs each day is not much more than is needed to sustain the existing living tissues. Small decreases in the amount of carbon fixed by the foliage due to ozone may start a slow decline of living tissue that eventually can lead to thinning of the crown and death of the tree. While few people weep for the air pollution caused death of a ponderosa or Jeffrey pine tree, the loss of a monarch sequoia like General Sherman due to air pollution would be regretted by many people.

Ken Stolte
Botanist
Research Branch
Air Quality Division



Restoring Native Vegetation at Nez Perce National Historical Park

On June 17, 1877, the U.S. Cavalry rode into the drainage of White Bird Creek to persuade the Nez Perces of Idaho and northeast Oregon into moving to a new reservation in northcentral Idaho. A force of 109 men descended the canyon walls to a hidden village of Indians led by Chiefs Joseph, White Bird, and Toohoolhoolzute.

An Indian truce party, approaching the advancing army, was met be a volley of gunfire. The Sunday morning quiet erupted into mayhem as the Nez Perce attacked and routed their adversaries. Sustaining heavy losses, soldiers retreated and the Battle of White Bird Canyon was quickly over. Ahead lay months of running battles as the Nez Perces evaded armies chasing them across Idaho, through Yellowstone, and finally to northern Montana where they were captured south of the Canadian border.

The canyon is quiet now except for the sound of passing cars. The battlefield, acquired in 1965 as a unit of Nez Perce National Historical Park, is disturbed only by seasonal sheep grazing and an occasional visitor. But the landscape has changed and continues to change. With the creation of the park, nearly 1,200 acres that included the battlefield were acquired by the federal government and nearly all contemporary land uses stopped. Natural processes remained to dynamically work the landscape.

White Bird Canyon today is quite different from its historical appearance. Abundant native plants are gone, displaced by invading annuals and weeds. The waist-high native grass that concealed the combatants in 1877 has been replaced by ankle-high species from the Middle East and Eurasia.

But, another battle is about to be waged at White Bird. A revegetation plan, based on a 1988 inventory and monitoring program, was developed by the National Park Service in 1989. Basing strategies on that plan, the Soil Conservation Service, Bureau of Land Management, Idaho Department of Fish and Game, and the National Park Service will begin an aggressive project in 1990 to stop the spread of alien species and return the battlefield to its historical appearance. The project will include park neighbors doing critical work.

The effort is a two-pronged approach. Approximately 350 acres of the site were historically farmed and will be cultivated again to control weeds and prepare a seedbed. Following two or three years of farming, it will be seeded to native perennial species. Dormant season grazing will control annual grasses on the remaining 800 acres. The 1988 inventory by the CPSU at the University of Idaho identified perennial plant species still growing at the site but deteriorating because of competition. Grazing pressure on annuals will let the perennials renew their vigor and competitiveness.

Goals of this project are to establish a native grassland community, improve habitat for wildlife, reduce wildfire potential, and improve the site's interpretive potential. The project is significant in its size, methodology, and level of interagency and community involvement. Everyone working on the effort is enthusiastic and willing to commit resources to its success.

Jan R. Dick
Chief Ranger
Resource Management and Visitor Protection
Nez Perce National Historical Park

Response of Black Bears to Gypsy Moth Infestation in Shenandoah National Park

The National Park Service is concerned about the effects of gypsy moth defoliation on large animal species, particularly the black bear. An understanding of how gypsy moth infestations may influence bear populations, habitat use, and movement patterns are important. A five-year research project was initiated with the U.S. Fish and Wildlife Coop Unit at the VPI to study the response of the black bear population in and around Shenandoah to gypsy moth infestations.

The effects of the gypsy moth in the park increased dramatically in 1989. Nearly 45,000 acres were defoliated in the northern two-thirds of the park. Subsequently, all bears monitored in 1989 encountered significant levels of defoliation over at least part of their home ranges.

As of January 1, 1990, radio-transmitter collars were fixed to 19 females and 1 male residing in the North District of the park, and 7 females residing in heavily defoliated sections of the Central District. The collared bears were periodically located 1,511 times in 1989 by ground-based triangulation and aerial location via fixed-wing aircraft. Although the effects of gypsy moth defoliation and black bear movement patterns in the North District cannot yet be determined, some general movement patterns are evident.

During peak defoliation periods, at least 11 bears were repeatedly located in or near nondefoliated spray blocks along the Skyline Drive. However, many other bears did not use these areas and those that did were frequently located near the drive prior to defoliation of the adjacent areas. Unlike the summer of 1988, numerous sightings of both collared and unmarked bears were reported in nondefoliated areas by visitors and park personnel. These sightings tend to support an increased use of the spray block areas over that in the past.

The disproportionate use of small nondefoliated areas scattered throughout most of the monitored bears' home ranges is suspected. Even in nearly completely defoliated areas, some nondefoliated stands were available for bear use. However, the use of these stands will not be confirmed until digitized defoliation maps can be merged with bear locations and statistically analyzed.

Fall bear movements were not extensive in 1989. No bears made significant moves (> 10 km) before August and only seven individuals made significant fall movements. Little use of orchards and agricultural areas was recorded throughout the year. Two females moved 5 to 10 km west of the park; one appears to have permanently dispersed while the other made a two-week excursion in October and then returned to her previous home range. Only one of the remaining five bears exhibiting a "fall shuffle" left the park during the fall and she did so only briefly. The other four moved to other areas of the park.

Twelve acorn plots in mature chestnut oak/red oak stands were set up in 1989 to monitor fall acorn production. Preliminary examination of the acorns collected indicate that defoliated stands produced essentially no acorns. Acorn production in nondefoliated stands appears to have been good. Bears were, thus, expected to have encountered a severe lack of acorns in heavily defoliated areas in the fall.

The relationship of fall movements with defoliation is not clear. Since no movements occurred during peak defoliation periods, no evidence exists to indicate that bears attempted to relocate directly in response to canopy opening. However, at least some of these fall excursions are likely to have been in response to acorn crop failures induced by gypsy moth infestation. It is important to note that four of the areas visited by bears during the fall shuffle were significantly defoliated. Hence, moving did not necessarily increase the food available to these individuals, since acorns also were scarce in these portions of the park.

Collected scats in these areas revealed heavy use of grapes as food. Very few scats were found containing acorns. Consequently, quantities of soft mast may be more important during the predenning period for bears in the park than has previously been thought, especially during years of hard mast failures, whether gypsy moth induced or naturally occurring.

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Geological and Chronological Development and Evolution of Cumberland Island National Seashore

The construction of coastal engineering works and channel dredging over the past 100 years have had noticeable effects on St. Marys Entrance and Cumberland (Georgia) and Amelia (Florida) Islands. The additional construction and channel development at the Kings Bay Naval Trident Submarine Base and further deepening of the channel through St. Marys Entrance is expected to have significant impacts on the resources of Cumberland Island and Cumberland Sound estuary. The potential biophysical impacts of this construction project on the saltwater marshes of Cumberland Island and Camden County are being evaluated by this study (to 3500 years BP) and contract research by Woodward-Clyde, Inc. (present).

Cumberland Island lies in a region in which net sea level change over the past 100 years has been approximately +30 cm. Presumably, sufficient sediment supplies were available to allow mudflats and marshes to accrete at a rate sufficient to compensate for this increase in sea level, although this has not been documented. It is possible that the construction of the entrance channel to the U.S. Navy's East Coast Trident Submarine Base at King's Bay, Georgia, may affect the deposition of sediments on the mudflats and tidal marshes of Cumberland Island. The recent deepening of the channel to a 51-foot depth may further affect accretion and erosion on the mudflats and in the tidal marshes of the Island.

The mudflats, and tidal marshes and creeks, are important to the Cumberland Sound ecosystem. They provide habitat, and foraging and shelter areas, for numerous vertebrate and invertebrate species, including the endangered wood stork and manatee. These areas are also important in nutrient recycling. Interference with sediment deposition, both in terms of quantity and quality, could result in drowning of the marshes as sea level rises, and increased shoreline recession. In question is whether or not the deepening of the channel will affect the marshes of the Cumberland Island ecosystem. In order to answer this question we must know how the marshes existed in the past, how they evolved, and what environmental factors affected this evolution and development.

The principal objective of this study is to investigate and document the historical evolution and development of the marshes, mudflats, and marsh tidal creeks of Cumberland Island National Seashore. Other objectives include the evaluations of long-term changes in tidal creek morphology, creek bank slopes, and changes in relative area of marsh and mudflats. Predictions of future changes in marsh structure will be made.

Approximately 100, 2-to 4-meter length, sediment cores will be taken from the saltwater marshes of Cumberland Island and Camden County. Analyses include Carbon-14 dating, and paleonological and paleoecological habitat and community identifications.

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EPA Takes Emergency Superfund Action at McLaren Tailings Site

For many years, the National Park Service has been concerned about the potential release of hazardous substances from the McLaren tailings site into Yellowstone National Park due to a failure of the tailings dam and subsequent washout of the tailings. This site is located 5 miles upstream of Yellowstone on Soda Butte Creek near Cooke City, Montana, and such a release would result in significant, and possibly irreversible, adverse impacts to the aquatic, riparian, and related terrestrial resources of the park and also to the uses and values associated with these resources.

The National Park Service raised these concerns with the Office of Surface Mining (OSM) in order to possibly tap OSM's Abandoned Mined Land (AML) fund and with EPA to have McLaren designated as a superfund site. While both of these agencies shared NPS concerns, no action was taken because the threat associated with McLaren was to the "environment" and not to "public health and safety." As such, the AML funds could not be used (until such time as all abandoned coal lands in Montana are reclaimed) and the site did not achieve a high enough ranking in terms of EPA criteria and priorities to qualify for funding as a superfund site. However, based on (1) EPA policy changes in early 1989 with respect to using the superfund to protect the environment and (2) the findings of EPA-sponsored investigations at McLaren, which identified the high probability of dam failure due to flooding (particularly as a result of above normal snowpack in 1989 and the potential for increased runoff from the watershed above the tailings due to the fires of the summer 1988), EPA decided to take an emergency action under superfund at McLaren. This action consisted of modifying the Soda Butte stream channel adjacent to the tailings to accommodate flood discharges, thus, reducing the risk of dam failure. This action was EPA's first emergency action under superfund to protect the environment.

With the Bureau of Reclamation as its contractor, EPA carried out this emergency action in early May 1989. The timing of the action was fortuitous since a large flood event in Soda Butte Creek (which likely would have flowed across the tailings and possibly resulted in dam failure) occurred the day after the stream channel modification was completed. Discussions are currently underway with the private parties responsible for McLaren regarding possible removal of the tailings from the site and subsequent reprocessing and disposal at a nearby mill.

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and
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Chemical Fertility Control in Managing Assateague Ponies

Reducing fertility among free-roaming feral horses has been the goal of numerous earlier studies. Initial experiments at Assateague Island National Seashore, Maryland, resulted in an 83% decrease in foaling among feral mares bred by stallions treated with injectable microencapsulated testosterone propionate (mTP). Despite the pharmacological effectiveness of this treatment, which decreased sperm count and motility, cost-effectiveness and the stresses caused by immobilization made it clear that managing horse populations by fertility control would be difficult to achieve unless the contraceptive agent could be delivered remotely. In a second study the pharmacological effectiveness of mTP in stallions was confirmed, but difficulty was encountered in remotely delivering a sufficient mass of the steroid.

The objectives of the most recent study were to test the contraceptive efficacy of a porcine zonae pellucidae (PZP) vaccine in free-roaming feral mares, under field conditions, and to determine the effectiveness of remote delivery.

For the study, 29 mares were selected from 150 feral horses inhabiting Assateague. The ages and fertility records were known for almost all animals. The mares chosen for treatment were purposely selected for high fertility rates, with the treatment group averaging 10% higher than the overall herd rate over the preceding three years. Between February 29 and March 10, 1988, all 29 mares received an initial inoculation of vaccine via darting from the ground. Between the 12th and 21st of March, 26 of the 29 mares received a second inoculation. Between the 16th and 25th of April, 18 of the 26 mares which received the second inoculation also received a third inoculation. Identifying markings were recorded for each horse and the animals were observed throughout April for adverse effects.

During October 1988, five months after the last inoculation and two months after the breeding season, urine samples were collected from the 29 treated and 6 control mares, without capture. Urinary E_1S and nonspecific Po metabolite concentrations indicated that none of the 18 mares receiving three inoculations were pregnant, 1 of 8 receiving two inoculations was pregnant, and 1 of 3 mares receiving one inoculation was pregnant, and 3 of 6 control mares were pregnant. By August 1989, 2 live foals were present among the 29 treated mares, and 3 foals among the 6 control mares, precisely as predicted. Overall fertility rate of the 29 treated mares was 6.8% after treatment, versus 55.5% for each of the two previous pretreatment years, versus 50% for the 6 control mares in 1989, and versus 53.8% for all 13 untreated sexually mature mares in the study area in 1989. When the experimental population is confined to the 26 mares receiving two or three inoculations, the overall fertility rate for treated mares is 3.8%. Finally, in August 1989, a random sample of 7 treated mares was pregnancy tested by means of urinary steroid metabolites in order to test reversibility of the vaccine's antifertility effect; 3 were determined to be pregnant.

This study provides the first description of successful fertility inhibition among uncaptured free-roaming wildlife by means of remotely delivered immunocontraception. The success of the PZP vaccine in suppressing fertility among the Assateague feral mares is based on its ability to inhibit fertilization or possibly implantation.

A major advantage of the PZP vaccine is the small volume required and the aqueous base, both of which facilitate administration by dart. Remote delivery eliminates the need to capture horses, the attendant costs, and the likelihood of injury to the horses. Another advantage is the reversibility of the vaccine's contraceptive effects. The issue of reversibility is politically, as well as biologically, important since it is unlikely that public opinion will favor irreversible sterilization among feral horses.

The requirement for at least two inoculations for successful fertility inhibition is a current weakness. The technology to convert the PZP antigen into a single-dose vaccine already exists in the form of microencapsulation. Experiments are currently underway to assess the effectiveness of a single annual booster inoculation, once antigen recognition has occurred. If a booster is effective, it is probably possible to incorporate the booster in an initial inoculation which delivers an initial bolus of antigen, a second pulse of microencapsulated antigen a month later, and the microencapsulated booster a year later. The remote method of pregnancy testing and the remote delivery of PZP offers complete noncapture technology for feral horse contraception and evaluation of reproductive effects of treatment.

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Restoring Road Areas in Redwood National Park

The Redwood National Park expansion legislation directed that a rehabilitation program be developed for the disturbed lands being added to the park. Of the additional land, 75% was logged, containing over 300 miles of associated haul roads. The program's primary goals are to minimize man-induced erosion and to encourage the return of a natural pattern of vegetation. The ultimate goal is to restore the natural ecosystems to a condition similar to what would have existed without disturbance by man.

The preferred restoration technique for roads that are no longer needed or causing erosion problems is outsloping, or recontouring, so as to blend with the surrounding topography. This is generally done by a large excavator and bulldozer working together, retrieving sidecast road fill, placing it against the road's cutbank, then smoothing and blending the fill to match of the natural topography. This provides a permanent erosion control treatment, and restores natural hillslope runoff patterns. An outsloped surface does not allow runoff to divert or concentrate as do ditches, waterbars, or culverts, and it requires no maintenance. Outsloping can also speed reestablishment of native vegetation along road corridors by permitting retrieval of the original topsoil. Topsoil is the first material to be sidecast during road construction and is generally uncovered near the end of the outsloping process. This retrieved topsoil is protected with straw mulch when work is completed.

Recent observations of earlier revegetation efforts, some nearly 10 years old, show the benefits of recontouring road corridors by retrieving sidecast fill and returning the topsoil to the surface of the treated area rather than simply decompacting and draining these surfaces.

Refinements in equipment application and resulting decreased treatment costs allow recontouring and topsoil retrieval to be widely applied.

Fill material (mostly soil with some organics) placed into streams for construction of roads should be completely excavated to remove the potential sediment source and prevent the stream from diverting out of its natural channel. The excavation reexposes the natural streambed, usually a mixture of rock and organic debris. Excavated stream banks mimic and blend with hillslope topography above and below the road. This work is also performed with a large excavator and bulldozer. Proper stream excavation requires experienced geomorphologists to design and guide the work. Inexperience can lead to over- or under-excavation which can destabilize channels for many feet up and/or downstream.

Complete outsloping of road corridors and excavation of fill from stream crossings allows for complete landscape restoration and erosion control. It returns the roaded area to a naturally functioning hydrologic system, which sets the stage for recovery of the native biological ecosystem. These treatments are in accordance with National Park Service management policies and goals. Complete road removal also enhances the visitors experience by restoring aesthetic values.

Technology transfer has been an important aspect in the erosion control and watershed restoration program. Redwood National Park staff have assisted other parks and other federal, state, and local agencies in planning and implementing restoration work on lands under their jurisdiction.

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Redwood National Park

Restoring Flow to Shark Slough Basin at Everglades National Park

During 1989 the National Park Service and the U.S. Corps of Engineers, along with the South Florida Water Management District, worked to reverse decades of water flow restrictions that have severely impacted the Florida Everglades. The historical Everglades ecosystem once covered an area of approximately 4,000 square miles, extending from Lake Okeechobee to the downstream estuaries of Florida Bay. Major drainage and flood control projects in the northern Everglades began in the late 1800s, and by the 1950s, 35% of the historical Everglades had been lost to agricultural and residential development. By the early 1960s, another 30% of the Everglades was converted into five large water storage impoundments (Water Conservation Areas). An additional 10% to 15% of the Everglades, primarily east of the Water Conservation Areas, has been severely degraded by excessive drainage and invasion by exotic vegetation. The last 20% of the original Everglades wetlands is now managed by the National Park Service within Everglades National Park and the Big Cypress National Preserve. All of these upstream water management modifications have significantly altered the volume, distribution, and timing of surface water flows throughout the southern Everglades and Everglades National Park. The resulting changes in natural hydroperiods and surface water inundation patterns have been a primary cause of the dramatic declines in wildlife populations within the park.

Within the Shark Slough Basin, the original 25-mile-wide flow section was reduced to 10 miles and natural marsh sheetflow was replaced by deliveries through four large water control structures. This shifted surface water flows from the deeper eastern flowway into higher elevated marshes in western Shark Slough. This change caused the natural dry season pool to form outside the main channel of the slough where it is less persistent and less ecologically productive. The change from natural marsh flow to controlled water deliveries also reduced the natural buffering effects of the upstream wetlands and the original volume and timing of flows, related to upstream rainfall, was replaced by rapid canal flows that followed rigid upstream regulatory schedules.

In 1970, Congress passed Public Law 91-282, which established a guaranteed minimum monthly delivery schedule for Everglades National Park, but the timing and distribution of these flows continued to cause detrimental wildlife impacts in the park. By the late 1970s the National Park Service recognized that major improvements were needed to reestablish natural flow distributions within the Shark Slough Basin.

In 1983 Congress passed legislation to authorize a program of experimental water deliveries to Everglades National Park. Within the Shark Slough Basin, four iterative field tests have been undertaken, with the ultimate goal of developing an optimum water delivery plan.

During 1989 the National Park Service, the U.S. Army Corps of Engineers, and the South Florida Water Management District developed an alternative for restoring water delivery through a series of structures and operating criteria. The recent passage of the Everglades National Park Expansion and Protection Act, and its associated structural modifications, will provide the needed flexibility to restore natural hydrologic conditions and reduce the impacts of upstream water management. Further long-term monitoring and detailed research will be needed to test the effectiveness of these modifications and fine-tune the restoration efforts.

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Mass Mortality of Marine Seagrasses in Florida

The seagrasses of western Florida Bay, principally turtlegrass (*Thalassia testudinum*) have been dying over extensive areas since the summer of 1987. To date, severe die-off has occurred over 15,000 acres of bottom, with 50 to 60 thousand additional acres possibly impacted to a lesser degree. Die-off has also been observed in Pine Channel in the lower Florida Keys, in Biscayne National Park, and in state waters of eastern Florida Bay. Massive die-off of turtlegrass is unprecedented in tropical waters, and at this point the cause or causes of seagrass die-off in Florida Bay are unknown.

Marine biologists at the South Florida Research Center, Everglades National Park, have organized a team to investigate the cause of seagrass die-off. The team of biologists includes Paul Carlson and Mike Durako of the Florida Department of Natural Resources, David Porter of the University of Georgia, Joseph Zieman of the University of Virginia, and Ron Jones of Florida International University.

As of February 1990, findings indicate that die-off is first evident as small patches, then enlarges, and coalesces into larger and yet larger patches. Ultimately hundreds of acres of mud bottom devoid of seagrass cover are the result. These observations have suggested that seagrass die-off may be caused by a plant pathogen--a possibility which is being investigated. Seagrasses near the sites of die-off demonstrate signs of stress. Florida Bay is a naturally stressful environment for marine life because the bay is shallow, has poor circulation, and is frequently hypersaline. The possible role that stress plays as a cause of seagrass die-off is under investigation.

The loss of seagrass on the scale being observed in Florida Bay must result in both short- and long-term impacts. Short-term impacts may be largely negative such as reduced water clarity, algal blooms, channel sedimentation, and food and habitat loss to fish, shrimp, and wading birds. However, in the long-term, impacts may generally be positive because turtlegrass, where it has died, should be replaced by shoalgrass, (*Halodule wrightii*), a seagrass known to rapidly exploit denuded mud bottoms. Important for the ecological function of Florida Bay, shoalgrass is rich nursery habitat for pink shrimp and small fishes. Two year after seagrass die-off was first observed, recolonization by shoalgrass has begun. At present it seems that Florida Bay is beginning the recovery process. Seagrass is still dying, but much more slowly, in 1989. The state of Florida is funding research through the new saltwater fishing license.

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Winter Haze Intensive Tracer Experiment (WHITEX) Assesses Visibility Impairment at Colorado Plateau Parks

The Clean Air Act Amendments of 1977 established a national goal of remedying any existing and preventing any future man-made visibility impairment in class I areas. The Environmental Protection Agency published visibility protection regulations that allow the federal land manager to identify class I areas with existing visibility impairment, including any areas where such impairment might be reasonably attributable to specific sources. Several years ago, the Assistant Secretary for Fish and Wildlife and Parks informed the Environmental Protection Agency that Grand Canyon National Park had existing visibility impairment. Based on monitoring data collected by the National Park Service, the Navajo Generating Station (NGS) was identified as a suspected source.

The Navajo Generating Station is a large power plant that is owned by the Salt River Project (SRP) (21.7%), the Bureau of Reclamation (24.3%), the Los Angeles Department of Water and Power (21.2%), the Arizona Public Service Company (14%), the Nevada Power Company (11.3%), and the Tucson Gas and Electric (7.5%). The facility was built in the mid-1970s near Page, Arizona, just northeast of the park. The plant has never installed control devices to remove sulfur dioxide gas from its stack emissions. Even with the use of low sulfur coal, the plant emits 40,000 to 70,000 tons of sulfur dioxide per year.

For six weeks during January and February 1987, the National Park Service, with the Environmental Protection Agency and the electric utility industry, conducted the Winter Haze Intensive Tracer Experiment (WHITEX) to assess the feasibility of attributing wintertime visibility impairment at Colorado Plateau parks to the plant. WHITEX involved extensive air quality monitoring and data analysis, injection of a unique tracer gas into the NGS emission stacks, analysis of the meteorologic conditions of the area, and application of several different source attribution techniques to identify the cause of visibility impairment in the parks. To fulfill court-ordered regulatory requirements, the Environmental Protection Agency asked the National Park Service to use the WHITEX data to produce a report on the contribution of the NGS emissions to wintertime visibility impairment in the parks.

The WHITEX report concluded that the Navajo Generating Station was the largest single contributor to visibility impairment at Grand Canyon during the six-week winter study period, contributing over 40% on the average and 60-70% during specific episodes. WHITEX also shows that the types of meteorologic conditions conducive for the facility to impact the Grand Canyon occur frequently during the winter. Additional information appears to confirm the WHITEX conclusions. For example, SRP-performed studies in the early 1970s indicated that subsiding air motions and drainage flows toward the Grand Canyon occurred frequently from the NGS site anytime the air mass was cold and the winds were weak, not just during the winter. Furthermore, the state of Arizona has stated that the meteorology that prevailed during the WHITEX study period is generally representative of the 100 years of recorded meteorology for the winter period. However, their review also indicated that during the WHITEX study the conditions conducive for the NGS impact at the Grand Canyon occurred less frequently than the historical record would suggest. Finally, more recent NPS monitoring suggests that the degree of power plant pollution at the Grand Canyon measured on the rim during the WHITEX study may understate the power plant pollution that is trapped inside the Canyon during stagnation episodes.

Based on the NPS work and additional information, the Environmental Protection Agency proposed on September 5, 1989, to find the power plant a major contributor to the significant visibility impairment that affects Grand Canyon during the winter months. In mid-February 1990, the agency circulated a draft proposal that would require the generating station to install "best available retrofit technology" that would reduce the sulfur dioxide emissions by 90%. The Environmental Protection Agency estimates the costs of these controls over a 30-year remaining plant life at $0.98 to $1.37 billion, and the benefits from the pollution reductions over these 30 years at $2.1 to $3.1 billion. The EPA draft proposal is now under review by the Office of Management and Budget and interested federal agencies, including the National Park Service and the Bureau of Reclamation.

At the request of Secretary Lujan and with the co-sponsorship of the Environmental Protection Agency, the Department of Energy, and the Salt River Project, the National Academy of Sciences (NAS) has agreed to consider the contribution of WHITEX toward the science of source apportionment, in the context of a broader study on regional haze apportionment methods for all class I areas and alternative control technologies.

The first meeting of the NAS panel took place on March 28-31, 1990, at Grand Canyon National Park. The panel intends, if practical and appropriate, to prepare a report on WHITEX in time to benefit the current EPA rulemaking on the generating station.

The Salt River Project has publicly criticized the WHITEX report, though the Environmental Protection Agency has not been persuaded by the SRP criticisms to date. The Salt River Project is now analyzing the data from another wintertime study they conducted on the NGS impact on the Grand Canyon. The Salt River Project would like the Environmental Protection Agency to consider any new information produced by the new study, and the Environmental Protection Agency has proposed to consider relevant data provided by August 31, 1990.

The National Park Service has confidence in the WHITEX conclusions, supports the EPA finding of "attribution," and opposes unwarranted delay in the rulemaking. The National Park Service is looking forward to the NAS review, while recognizing the difference between the NAS inquiry into the scientific contribution of WHITEX, and the EPA inquiry into the reasonableness of requiring controls on the Navajo Generating Station.

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White-tailed Deer Study at Pennsylvania Parks

Gettysburg National Military Park and Eisenhower National Historic Site

The determination of appropriate deer population levels is a key aspect of managing deer in today's fragmented landscapes. The white-tailed deer is a native species of the eastern United States and is recognized as a component of the natural systems which the National Park Service is charged with protecting and maintaining. Recently, the size of the deer populations in many parks has reached levels where either noticeable changes to vegetative communities or threats to human safety have become a management concern. More than 20 studies on white-tailed deer have been conducted in the Mid-Atlantic, North Atlantic, and Southeast regions of the National Park Service since the late 1970s.

One such study was completed in 1989 in the Mid-Atlantic Region. The 7,069-acre study area in south-central Pennsylvania included Gettysburg National Military Park (3,732 acres), Eisenhower National Historic Site (690 acres), and adjacent private lands (2,647 acres). Park resource managers were particularly concerned about the intensive deer browsing of tree seedlings in historic woodlots, increasing consumption of farm crops by deer, and the high number of deer and automobile collisions. The study addressed deer population size, movements, and mortality in the Gettysburg study area, and deer movements, deer habitat use, and the impact of deer on forests and farm crops at the two park units.

The estimated number of deer in the Gettysburg study area increased from 1,012 in November 1987 to 1,254 in November 1988. The number of deer per square mile ranged from 64 to 114; however, one area of about 1 square mile in size had approximately 176 deer in April 1988. Approximately 93% of the estimated deer population was found in the southern sector, which included all of Eisenhower and the southern part of Gettysburg and comprised 76% of the study area.

Deer movements were monitored from 1985 through 1987; 47 radio-collared deer were located a total of 7,921 times. Due to the daily deer movements, their proximity to private lands, and the size and shape of the two park units, deer frequently crossed the boundary lines between public and private land in the Gettysburg study area. The migrations and dispersal movements strongly indicate that deer readily traveled between the Gettysburg study area and the surrounding townships of Adams County.

Recent studies of managed northern hardwood forests in Pennsylvania indicated that more than 51,000 seedlings (of all tree species combined) per acre should be available in order to regenerate hardwood forests. Within the two parks, an average of half of the seedlings needed were available, with the most common being white ash and white oak averaging 10,700 seedlings per acre of both species combined.

In 1987, corn yield was reduced by 33% in the two park units due to deer, and estimated crop loss ranged from 17% in the northern sector to 63% in the southern sector. Grain yield of winter wheat was reduced 30% in the parks by deer, and estimated crop loss ranged from 14% in the northern sector to 43% in the southern sector. Some wheat and corn fields in the southern sector were a complete loss to the farmers due to deer feeding from greenup until harvest time.

Deer mortality was also examined; 50 deer were killed by automobiles within the Gettysburg study area in 1985 compared to 64 in 1986 and 108 in 1987. Of the marked deer, 2 of 25 were killed by automobiles in 1985, 11 of 77 in 1986, and 7 of 86 in 1987. Hunters shot 4 of 25 marked deer in 1985, 10 of 77 in 1986, and 5 of 86 in 1987, all on private land.

The study concluded that the white-tailed deer are a valuable component of Gettysburg National Military Park and Eisenhower National Historic Site, but deer density should be maintained at a level that is at or below the level recommended for Adams County by the Pennsylvania Game Commission. Currently, the Commission's goal for Adams County is an over-wintering deer density of 20 per square mile of forest land, with the number of deer assigned to farmland set at 0. The researchers concluded that the size of the November 1988 deer population of approximately 400 per square mile of forest land in the Gettysburg study area has exceeded the level that is compatible with regeneration of woodlands and historic woodlots, production of farm crops, and safe travel on roadways.

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As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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